Reproductive Studies on Preparation of Whiteleg Shrimp *Litopenaeus vannamei* Broodstock in Commercial Hatcheries

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Abstract: The current study was conducted to identify and analyze the best practices that can be followed in the white leg shrimp *(*Litopenaeus *vannamei*) hatcheries for the good preparation of the broodstock applying for a period of 30 days and to indicate the readiness of the broodstock to start the hatching season. Three feeding programs which have two types of worms (blood worms and clam worms) were used, where the first treatment fed on 100% of (bloodworms), the second treatment fed on (blood worms and clam worms 50%:50%), However the third treatment fed on100% (clam worms). The experiments were evaluated in terms of (broodstock spawning rate – Gonadosomatic index - number of eggs - hatching rate - number of nauplii and number of spawning cycles). The results showed that the feeding protocol that contains blood worms increase the quality and efficiency of reproductive performance of white leg shrimp (*L. vannamei*), as it contained higher percentage of protein, vitamins, minerals, amino acids and unsaturated fatty acids, which are of great importance in the process of hatching and producing egg. In the present study, the feeding regime T1 which consists of 12% blood worms, 12% squid and 1% dry pellets showed the best reproductive performance of *L. vannamei* than other feeding regime while group of shrimp fed on clam worms showed lowest quality and reproductive performance.

Keywords: Worms, *L. vannamei*, hatching rate, fecundity, number of nauplii

INTRODUCTION

Aquaculture, which accounts for more than half of global fish production, is the fastest growing sector of food production with around 424 aquatic species grown globally, and benefits many people by providing nutrition food security, stable livelihoods, and poverty reduction (Galappaththi *et al*., 2020). Total fisheries and aquaculture production reached an all-time record of 214 million tonnes in 2020, comprising 178 million tonnes of aquatic animals and 36 million tonnes of algae, a slight increase (3%) from the previous 2018 record (213 million tonnes). The limited growth is mainly caused by a 4.4% decline in capture the impacts of the COVID-19 pandemic in 2020. This decline was compensated for by a continued growth of aquaculture, albeit at a slower yearly rate in the last two years. Of the overall production of the aquatic animals, over157 million tonnes (89%) were used for human consumption. the remaining 20 million tonnes were destined for non-food uses to produce mainly fish meal and fish oil (FAO, 2022). Aquaculture in Egypt was 2.1 mt (GAFRD, 2020) which considered a huge and great success story. In addition to many natural and artificial lakes with different characteristics and the presence of the Nile River, there are vast areas of aquatic fisheries, but these sources are not sufficiently exploited (Kaleem, 2021). Shrimp are the most valued commercial crustaceans all over the world. Shrimp now ranks second in value terms. shrimps- farming can help to reduce pressure on overexploited wild stocks from fisheries, in terms of natural resources protection (FAO, 2022). Shrimp production around the world has increased significantly over the past two years. World shrimp aquaculture production has grown dramatically from 200,000 tons in 1985 to nearly 2.7 million tons in 2005 (Megahed *et al*., 2013). Many countries are moving from Penaeus monodon to the white prawn *Litopenaeus vannamei* as the main species in shrimp farming. Recently, *L. vannamei* has become more important compared to *P. monodon* in terms of contributing to the world's total shrimp aquaculture production. *L. vannamei* is now grown everywhere in Southeast Asia (Rosenberry, 2011).

The focus on *L. vannamei* production is partly due to the advantages over *P. monodon* with respect to pathogen resistance. Furthermore, the species have an increased tolerance for high stocking densities (such as 60-150 per square meter, but up to 400 per square meter) better feed conversion rate and lower protein requirements (about 20–35% crude protein). The average highest growth rates (up to 3g 1 week), high tolerance to a wide range of water parameters, including salinity and temperature, and higher survival rates during larval stages (50-60%). Additionally, in terms of marketing, customers have been shown to prefer *L. vannamei* over *P. monodon* (Bardera *et al*., 2019). Whiteleg shrimp post larvae production based on applying best practices in the hatcheries including, broodstock selection, feeding practices, broodstock preparation, larval rearing, and broodstock management. Regarding the commercial hatcheries most of them following similar practices in the broodstock preparation as feed quality and quantity, rearing units, and the different environmental parameters (Racotta *et al*., 2003). The limited and inconsistent availability of wild shrimp larvae combined with the urgent need to establish selective breeding programs has led to increased interest in captive reproduction of penaeids worldwide. The technique of breeding in captivity is available for many species. Availability of an optimal diet has been identified as a critical factor for the sexual maturity and reproduction of shrimp (Wouters *et al.*, 2001). The most important characteristic of aquaculture species is the ability to control reproduction and to produce viable offspring from captive spawning

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(Balasubramanian and Vijayan, 2020). Several factors have a significant impact on the quality and quantity of eggs, such as broodstock age and/or size, type of endocrine manipulation, genetic variance, and feeding of the broodstock (Racotta *et al*., 2003). Nowadays, the shrimp industry uses a variety of fresh feeds such as cuttlefish, bivalves, and polychaetes, along with other artificial diets. Among these species, brine shrimp biomass and live brine shrimp biomass are indispensable for shrimp ripening stages due to their better fatty acid properties and the presence of hormonal active substances. Nutrition is generally provided by 25% and recently increased up to 50% of body weight (Vijayan *et al*., 2018).

Feeding systems are based on a wide range of frozen marine animals, including squid, various mollusks (mussel sand oysters), marine mulches, and crustaceans (shrimp, crabs, and enriched brine shrimp biomass). Even beef or pork liver is frequently used in white leg shrimp hatcheries, frequent use of squid, marine worms and mollusks as basic food ingredients due to their positive effect on penaeid shrimp reproduction and because of the high levels of polyunsaturated fatty acids (Wouters *et al*., 2001; Coman *et al*., 2007). For example:

1- Squid is used to feed shrimp broodstock, fresh or frozen squid is usually sliced before feeding into shrimp spawning tanks. Squid meat is an excellent source of cholesterol, an essential nutrient for shrimp growth and successful reproductive performance (Akiyama, 1992).

2- Mussels, clams and oysters are commonly feed for shrimp broodstock either fresh live or frozen meat mollusk meat is a good source of essential nutrients for shrimp and, possesses excellent chemo-attractant properties (Hertrampf and Piedad-Pascual, 2012).

3- Marine polychaetes worms is considered essential for successful nauplii production in *Penaeus vannamei* (Browdy *et al*., 1996). Feeding of polychaetes can enhance reproductive performance of shrimp due to their high nutritional composition, high unsaturated fatty acid content (e.g., arachidonic acid) and the presence of reproductive hormones (Meunpol *et al.,* 2005).

4- The development of a broodstock diet capable of replacing fresh food is a priority. Many advantages can be expected from dry industrial diets over fresh foods, for example reliable supply, repeatable and controllable quality, ease of use, improved storage stability, reduced tank contamination, reduced risk of disease onset and easier delivery of chemical drugs, immunostimulants, and hormones (Harrison, 1997).

Therefore, this study was to determine the different feeding regime of white leg shrimp (*L. vannamei*) broodstock preparation in order to achieve the best reproduction performance.

MATERIALS AND METHODS

Experimental design

This study was conducted in private marine hatchery (El Ekhlas) which located in El Diba village in Port Said governorate. Three experimental feeding regimes were used in order to prepare the female broodstock for the spawning season, which consisted of the presence of polychaeta worms, squid and dry feed in different proportions. The experiment was carried out for 30 days, where the broodstock were fed in equal proportions, the percentage of (polychaeta worms was 12%, squid was 12%, and the dry feed was 1%) daily.

Rearing of broodstock:

L.vannamei broodstock reared from average initial body weight of 1.5g to average 25:30 g in the hatchery. During culture period, the shrimp were fed with commercial diet which contained around crude protein 38%, crude fat 8%, fiber 5.9 and energy about 4000 kCal. Growth was monitored every month by measuring weight and length of shrimp for 9 months until reach to 25:30g which are categorized to about 700 males and 700 females and transferred to controlled tank for adaptation. During adaptation period, shrimp were selected according to desired weight, healthy condition and normal genital organ

Experimental facilities:

The experiment was carried out in circular-shaped tanks, where the volume of each tank was 4 m3, its diameter was 3 meters, and its depth was 1.1 meters, where the bottom of the tank was conical in shape with central drainage and the color of the tank was light blue (Table 1). Each tank had 140 animals, with a density of 15 animals / m2 and the height of the water column was of between 50: 70 cm. Water change rate was 100: 150% of the total volume of the tank where the change is 70% in the morning and 80% at night, the photo period was adjusted at the lighting system 14 hours from 6 am to 8 pm and the dark system 10 hours from 8 pm to 6 am.

Feeding The predominant feeding practice in shrimp hatcheries and in shrimp broodstock trials has been used fresh feeds such (blood worms (*S. dibranchiata*), clam worms (*S. succinea*), frozen squid) and dried pellets (Table 2).

Table (1): Experimental units used during spawning and reproduction of *L. vannamei* broodstock

Experimental units	Volume	Material	Shape	Color	Dimensions m	Capacity
Maturation tanks	4 m^3	Fiberglass	Circular conical	Light blue	3*1.1	**50%**
Spawning & hatching tanks	500 L	Fiberglass	Circular conical	Black	1*0.75	**85%**
Basin for eyestalk ablation	500L	Plastic	Circular flat	White	1*0.6	**90%**
Egg & nauplii collector bucket	50 L	Plastic	Circular flat	White	0.4*0.5	**50%**

Table (2): Proximate chemical analysis of feeding protocol types used in the experiment

Item	Dry matter	Protein %	Lipids%	Ash%	NFE	Moisture%
Blood worms	28.3	59.3	16	7.8	16.9	71.7
Clam worms	16.5	56.3	14	9.2	20.5	83.5
Squid	19.3	80.9	7.5	1.5	10.1	80.7
Dried pellets	90	38	8	7	30.1	10

Table (3): Essential amino acids content of polychaetes worms based on dry matter

EAA	Lysine	Cysteine	Arginine	Isoleucine	Leucine	Tryptophan	Threonine	Valine	Histidine
W1	3.6	0.1	1.1	2.3	1.5	2.7	2.1	2.1	0.8
W2	2.6	0.1	0.7	2.8	1.4	1.9	2.05	2	0.7
W3	2.3	0.3	0.43	2.4	1.1	1.6	1.6	1.8	0.3

W1**: (blood worms), W2 (mix of blood worms and clam worms), W3 (clam worms)** *EAA: Essential amino acids and **TAA: Total amino acids

Three replicates for each of the feeding treatments T1, T2, T3 (Table 3), where the fiberglass circular tanks were filled with water that was filtered with a 5-micron filter bag until reaching a water volume of 4 m^3 for each tank. The water was heated until it reached a temperature of 26°C, lighting period was 14 hours, and dark period was 10 hours. The water change ranged between 100 and 150 % every day and the females were stocked with a density of 70 females in each tank to start feeding treatments that depend on worms, squid and dry food for 10 days as shown in the Table (4).

Table (4): First (T1), second (T2) and third (T3) feeding regime of female *L. vannamei* broodstock for 10 days

	Blood worms	Clam worms	Squid	Pellets
T1				
%/ meal	6	---	4	1
Feeding time/day	2	---	3	1
% / day	12	---	12	1
Q/day (g)	283	---	283	23
Q/period(g)	2830	---	2830	230
T2				
%/meal	3	3	4	1
Feeding time	1	1	3	1
%/ day	6	6	12	1
Q/day (g)	135	135	283	23
Q/period(g)	1350	1350	2830	230
T3				
%/meal	---	6	4	1
Feeding time	---	2	3	1
%/ day	---	12	12	1
Q/day (g)	---	283	283	23
Q/period(g)	----	2830	2830	230

(% meal) = percentage of various feeding stuffs in one meal. **(Feeding time/day)** = number of feeding time all the day depending on feeding regime scheme of feed stuffs. **(%/day)** = total percentage of feeding stuffs all day. **(Q/day)** = quantity of feed in the meal **(Q/period)** =quantity of feed during 10 days.

Eyestalk ablation for female *L. vannamei* broodstock:

The endocrine gland present in the eyestalk of the crustaceans is responsible for the blocking of certain activities connected with the gonadal maturation so the removal or blocking of this hormone from its activity is believed to help in the speedy maturation of the animals (Panouse, 1943). The females are collected from each experimental tank and placed in the plastic basin as previously mentioned. The surgical scissors are heated from both ends until complete redness. Then one eyestalk of the female’s eye is carefully cut and the female is dipped in an iodine antiseptic solution for sterilization. The females are returned to the original maturation tank and the previous process is repeated for each female.

Matting and spawning:

Males and females are mated in a 1:1 ratio, (70 males+ 70 female) are placed with each other in the tanks. The selected mated shrimp feed with the same three treatment of previous feeding regime which adjusted to the current total biomass in the maturation tank, so that the number of broodstock in each tank is 140 animals, with a density of 15 animals /m^2 as shown in Table (5).

Table (5): Protocol of Preparing *L. vannamei* broodstock for spawning

	Time	Parameter
Stocking density		140 animal/tank
Sex ratio		1:1
Water exchange	Morning	70%
	Evening	80%
Temperature		26:27°C
Dissolved oxygen		5:7 ppm
Photoperiod	Light	14 h
	Dark	10 h
Feeding time	08:00 am	Polychaetes worms
	12:00 pm	Frozen squid
	04:00 pm	Frozen squid
	08:00 pm	Polychaetes worms
	12:00 am	Frozen squid
	04:00 am	Dried pellets

Spawning and hatching:

Mated shrimps were placed in individual black fiberglass spawning tanks, where volume of 500L. They were filled with 30°C water to create a heat shock for the broodstock, then, throw their eggs. Addition of EDTA solution to precipitate heavy metals at a rate of 5 g/tank, and eggs are collected from these tanks after 5 to 7 hours from stocking the females the eggs are collected from spawning tanks and a representative sample is taken after good stirring through a pipette size of 1 ml. The eggs are counted and from the number of eggs that have been thrown by the females in the tank, eggs are placed in the fiberglass hatching tanks with stocking density1500 egg/L for48 hr. at temperature of 31°C then newly hatched fry were collected and counted.

Reproductive parameters of *L. vannamei*:

Reproductive performance was assessed for a series of standardized parameters over 30 days after successful spawning,

- Number of females which reach to ripe stage (selected female)
- Number of females which already fully spawned (spawned female)
- Gonado somatic index (GSI) = (ovaries weight /shrimp body weight)*100 (Ohtomi and Yamamoto 1997)
- Total number of eggs per females (fecundity) was calculated using a 1 mL pipette sub-sampling method with three replicates after eggs had been homogenized in harvest bucket.
- Total number of nauplii was measured using the approach as used for egg counting on the second day after 30 h which nauplii had hatched.
- Hatching rate was measured as the percentage of hatching nauplii per spawning event as (number of nauplii/number of eggs) × 100%
- Number of egg / females calculated by dividing the number of eggs per spawn by spawned female.

-Spawning cycle the number of successful spawning events was recorded for each surviving broodstock female at the end of the experiment.

Statistical analysis: values were subjected to one-way ANOVA which all the statical analysis were calculated using SPSS program version 20. Values are given as mean ± SE, mean was tested for significant differences at p value ≤0.05 (Duncan, 1955).

RESULTS

Results of reproductive performance of *L. vannamei* (Table 6) during the experimental period (30 days) showed a significant difference (P≤0.05) of the number of selected females, spawned females, GSI, fecundity, number of nauplii, hatching rate number of eggs per female and the spawning cycle. The highest values were observed at T1 which females were fed blood worm as shown in Table (4) and figures 1 and 2, while the lowest values were observed in females fed clam worm (T3).

Table (6): The effect of three experimental feeding regimes on the reproductive performance of *L. vannamei* during the experimental period

Measurements	T1	T2	T3
G S I %	5.53^{a}±0.20	4.55^{b}±0.11	4.05^{b}±0.10
Fecundity (n*10^6)	35.9^{a} 0.06	24.06^{b} ± 0.04	15.33^{c} ± 0.03
Nauplii (n*10^6)	28.20^{a} ±0.53	14.40^{b} ±0.03	7.60^{c} ±0.02
Hatching rate (%)	78.39^{a} ±0.96	58.86^{b} ±1.07	48.50^{c} ±1.58
Egg/female (n*10^6)	0.20^{a} ±0.001	0.19^{b} ±0.001	0.19^{b} ±0.003

Mean values in the same row with different superscript are significantly different (P≤0.05)
T1: first feeding regime1, **T2**: second feeding regime and **T3**: third feeding regime.

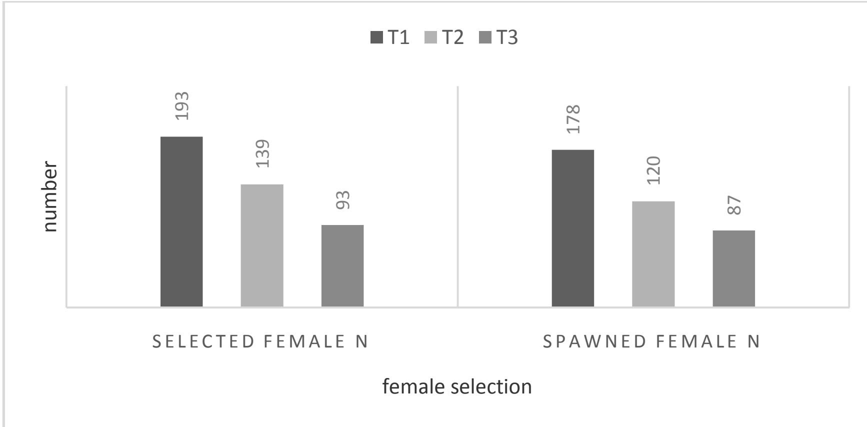

Figure (1): The effect of three experimental feeding regimes on the selected and spawned females of *L. vannamei* during the experimental period

T1: first feeding regime1, **T2**: second feeding regime and **T3**: third feeding regime

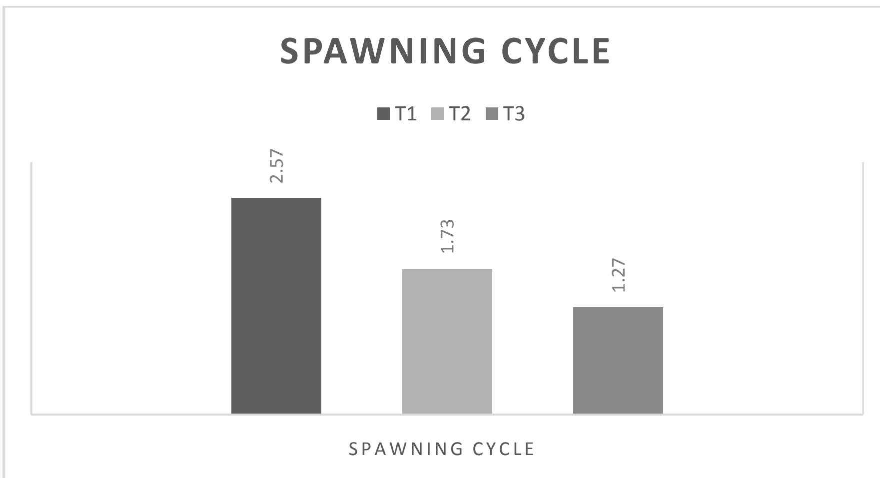

Figure (2): The effect of three experimental feeding regimes on the spawning cycle of *L. vannamei* during the experimental period

T1: first feeding regime1, **T2**: second feeding regime and **T3**: third feeding regime

DISCUSSION

An improvement in broodstock nutrition and feeding has been shown to greatly improve not only egg and sperm quality but also seed production. Thus, during the last two decades, more attention has been paid to the level of different nutrients in broodstock diets (Wouters *et al.,* 2001). An overview is given of the efforts to reveal the nature of maturation-stimulating factors in fresh food, and of the use and performance of commercial and experimental artificial diets. The availability of an optimal diet is identified as a crucial factor for the sexual maturation and reproduction of shrimp.

Results of reproductive performance of *L. vannamei* during the experimental period (30 days) showed a significant difference of the number of selected females, spawned females, fecundity, number of nauplii, hatching rate number of eggs/female and the spawning cycle. The highest values were observed at T1 which females were fed blood worm. In the present study the weight of the ovaries of maturing *L. vannamei* increased in GSI values and reached 5.53 in T1 and these results are in agreement with Ravid *et al.* (1999) who mentioned that weight of the ovaries of maturing shrimp increased four- to nine-fold in approximately 1 week and in that time sufficient nutrients need to be accumulated into the egg yolk to sustain the normal development of the embryos and pre-feeding larvae. Comen *et al.* (2005) found that egg fecundity of several families of pond reared tiger shrimp breeder ranged from 56,260-167,710 eggs/broodstock, 11-17 months of age. Similar results were observed to our study by Laining *et al.* (2014) who mentioned that shrimps were fed with combination diets consisting of 20% squid, 5% bivalves, and 70% high protein pellet until eight months of age and from 8 to 11 months of age fed with 30% squid, 20% mussels, and 5% polychaetes combined with 45% pellet. Among natural fresh feed that were extensively used for gonadal maturation and spawning of penaeid shrimp, the best is squid and polychaete sea worm (Meunpol *et al.,* 2005). The polychaetes are likely to become increasingly important as a resource in relation to the development of aquaculture for crustacean (Milada Safarik, 2007) since it has been found that polychaetes can provide a nutritionally correct balance of polyunsaturated fatty acids, which are essential for egg maturation in cultured prawns (Lytle *et al.,* 1990) or can provide other factors are essential for egg maturation (Croz *et al.,* 1988). In addition, polychaete worms may cause better absorption of chemical compositions like cholesterol and long chain unsaturated fatty acids (HUFA), which are effective for growth of ovary and production of eggs with high quality (Alireza Salarzadeh, 2014) and also diets that lack essential fatty acids delay shrimp growth (Millinema *et al.,* 1986; Sudaryono *et al.,* 1995). The preference of polychaetes as feed for crustaceans is attributed to their contents of a suitable balance of nutrients and several other factors promoting crustacean reproduction (Palmer et al., 2014). However, the nutritional value of polychaetes as well as other diets can vary with species, season of harvest and life stage (Chimsung, 2014). It has been reported that an unbalanced or incomplete diet causes poor reproductive performance or may even stop animals from reproducing (Bray and Lawrence, 1992). Harrison (1997) reviewed work published from the 1970s till the early 1990s with respect to nutrient metabolism during maturation and nutrient requirements for crustacean reproduction. Since then, nutrition research focused on lipid and vitamin requirements, the identification of maturation-stimulating compounds and the development of artificial diets. Among natural fresh feed that were extensively used for gonadal maturation and spawning of penaeid shrimp, the best is squid and polychaete sea worm (Yano, 2000; Meunpol *et al.,* 2005). From the earlier studies, it was evidently understood that nutrition is an important factor in growth and breeding of penaeid shrimps, and yet, knowing shrimp nutrition requirements is essential for successful management of broodstock (Alireza Salarzadeh, 2014). 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Polychaetes are not only an excellent source of highly unsaturated fatty acids (HUFA) but possibly also a good source of reproductive hormones, similar to those found in shrimp. To date, reproductive hormones of polychaetes such as progesterone and 17-hydroxyprogesterone have been reported to be capable of inducing shrimp oocyte development (Meunpol *et al.,* 2007). In addition, prostaglandin extracted from polychaetes had a positive effect on oocyte maturation especially during the late maturation and ovulation period (Meunpol *et al.,* 2010). The success of several fresh food items is attributed to their cholesterol content (e.g. squid, clam). Cholesterol is indeed known to fulfill several endocrinological functions, and its mobilization during maturation was reviewed by Harrison (1990). Protein requirements are assumed to be higher during maturation and reproduction of animals as compared to the non-reproductive stages, given the intense biosynthesis that takes place during these processes (Harrison, 1990). Deshimaru (1982) recommends dietary amino acid profiles similar to those found in fresh food commonly used in maturation diets. Castille and Lawrence (1989) demonstrated an increase in carbohydrate levels of the ovaries of *Far. aztecus* and *L. setiferus*. Carbohydrates are also excellent binders in diet formulation (Wouters *et al.,* 2001) and play an important role in glycogen accumulation in the hepatopancreas and also act as binders and transport of nutrients in the hemolymph (Harrison, 1997). In the present study, it could be concluded that the feeding regime T1 which consists of 12% blood worms, 12% squid and 1% dry pellets showed the best reproductive performance of *L. vannamei* than other feeding regime.

REFERENCES

Akiyama, D. M. (1992). Future considerations for shrimp nutrition and the aquaculture feed industry. Proceedings of the special session on shrimp farming, World Aquac. Soc., Baton Rouge, Louisiana, USA.

Alireza Salarzadeh (2014). The Effects of Different Diets on Ovary Maturation and Spawning of Pond-reared White Indian Shrimp (*Fenneropenaeus indicus*). Bulletin of Pure & Applied Sciences-Zoology, 33(1, 2): 19-27.

Balasubramanian, C. P. and K. K. Vijayan (2020). Reproduction endocrinology in Aquaculture with special reference to captive maturation of penaeid shrimps. Book: Molecular and biotechnology for fisheries: Training manual publisher: ICAR-CMFRI, Kochi, Kerala, India.

Bardera, G., N. Usman, M. Owen, D. Pountney, K. A. Sloman and M. E. Alexander (2019). The importance of behaviour in improving the production of shrimp in aquaculture. Reviews in Aquaculture, 11(4): 1104-1132.

Bray, W. A. and A. L. Lawrence (1992). Chapter 5 - reproduction of *Penaeus* species in captivity. Marine shrimp culture. Fast and L. J. Lester. Amsterdam, Elsevier: 93-170.

Browdy, C. L., K. McGovern-Hopkins, A. D. Stokes, J. S. Hopkins and P. A. Sandifer (1996). Factors affecting the reproductive performance of the Atlantic white shrimp, *Penaeus setiferus*, in conventional and unisex tank systems. Journal of Applied Aquaculture, 6(1): 11-25.

Castille, F. L. and A. L. Lawrence (1989). Relationship between maturation and biochemical composition of the gonads and digestive glands of the shrimps *Penaeus aztecus* Ives and *Penaeus setiferus* (L.). J. Crustacean Biol., 9(2): 202-211.

Chimsung, N. (2014). Maturation diets for black tiger shrimp (*Penaeus monodon*) broodstock: a review. Songklanakarin Journal of Science & Technology, 36(3): 265-273.

Coman, G., S. Arnold, T. R. Callaghan and N. Preston (2007). Effect of two maturation diet combination on reproductive performance of domesticated *Penaeus monodon*. Aquaculture, 263: 75-83.

Coman, G. J., P. J. Crocos, S. J. Arnold, S. J. Keys, B. Murphy and N. P. Preston (2005). Growth, survival and reproductive performance of domesticated Australian stocks of the giant tiger prawn, Penaeus monodon reared in tanks and raceways. J. World of Aquaculture Soc., 36: 464-479.

Croz, L., L. Wong, G. Justine and M. Gupta (1988). Prostaglandins and related compounds from the polychaete worm *Americonuphis reesei* Fauchald (Onuphidae) as possible inducers of gonad maturation in Penaeid shrimps. Revista de Biologia Tropical, 36: 331-332.

Deshimaru, O. (1982). Protein and amino acid nutrition of the prawn, Penaeus japonicus. Proceedings of the 2nd International Conference on Aquaculture Nutrition: Biochemical and Physiological Approaches to Shellfish Nutrition. World Mariculture Society, Special Publication, vol. 2, Louisiana State University, Baton Rouge, Louisiana, USA, pp. 106-122

Duncan, D. B. (1955). Multiple ranges and multile F-testes. Biometrics Fisheries Resources, 11: 1-42.

FAO (2022). The State of World Fisheries and Aquaculture. Rome, Italy, FAO.

Galappaththi, E. K., S. T. Ichien, A. A. Hyman, C. J. Aubrac and J. D. J. R. I. A. Ford (2020). Climate change adaptation in aquaculture. Reviews in Aquaculture, 12(4): 2160-2176.

Harrison, K. E. (1990). The role of nutrition in maturation, reproduction and embryonic development of Decapod crustacean: A review. J. Shellfish, 6: 1-28.

Harrison, K. E. (1997). Broodstock nutrition and maturation diets. Crustacean nutrition, 6, 390-408.

Hertrampf, J. W. and F. Piedad-Pascual (2012). Handbook on ingredients for aquaculture feeds, Springer Science & Business Media.

Kaleem, O. and A. -F. Bio Singou Sabi (2021). Overview of aquaculture systems in Egypt and Nigeria, prospects, potentials, and constraints. Aquaculture and Fisheries, 6(6): 535-547.

Laining, A., Usman and Muslimin (2014). Growth and reproductive performances of pond reared tiger shrimp, Penaeus monodon, fed different combinations of maturation diets. Indonesian Aquaculture Journal, 9(1): 67-77.

Lytle, J. S., T. F. Lytle and J. T. Ogle (1990). Polyunsaturated fatty acid profiles as a comparative tool in assessing maturation diets of Penaeus vannamei. Aquaculture, 89: 287-299.

Megahed, M. E., S. Ghoneim, G. Desouky and A. E. Dakar (2013). Pilot experiment on Shrimp *P. semisulcatus* production at Al–Deba farm site. Journal of the Arabian Aquaculture Society, 8(2): 331-338.

Meunpol, O., E. Duangjai, R. Yoonpun and S. Piyatiratitivorakul (2010). Detection of prostaglandin E2 in polychaete *Perinereis* sp. and its effect on *Penaeus monodon* oocyte development in vitro. Fisheries Science, 76(2): 281-286.

Meunpol, O., S. Iam-Pai, W. Suthikrai and S. J. A. Piyatiratitivorakul (2007). Identification of progesterone and 17α-hydroxyprogesterone in polychaetes (*Perinereis* sp.) and the effects of hormone extracts on penaeid oocyte development in vitro. Aquaculture, 270(1-4): 485-492.

Meunpol, O., P. Meejing and S. Piyatiratitivorakul (2005). Maturation diet based on fatty acid content for male *Penaeus monodon* (Fabricius) broodstock. Aquaculture Research, 36(12): 1216-1225.

Milada, Safarik (2007). Aquabait Marine Worm Farm and Sustainability Case Study in Aquaculture. Aquabait, Pty Ltd.

Millamena, O. M., J. H. Primavera, R. A. Pudadera and R. V. Caballera (1986). The effect of diet of the reproductive performance of pond-reared Penaeus monodon Fabricius broodstock; In Maclean J.L., Dizon L.B. and Hosilos L.V. (eds.); The First Asian Fisheries Forum; Manila, Philippines; pp. 593-596.

Ohtomi, J. and S. Yamamoto (1997). Change in gonadosomatic index with ovarian maturation in Jack-knife shrimp *Haliporoides sibogae* off south-western Kyushu, Japan. *Fisheries science*, *63*(6): 1044-1045.

Palmer, P. J., S. Wang, A. Houlihan and I. Brock (2014). Nutritional status of a nereidid polychaete cultured in sand filters of mariculture wastewater. Aquaculture Nutrition, 20(6): 675-691.

Panouse, J. B. (1943). Influence de l'ablation du pedoncle oculaire sur la croissance de l'ovaire chez la crevette Leander serratus. CR Acad Sci Paris, 217: 553-555.

Racotta, I., E. Palacios and A. M. Ibarra (2003). Shrimp larval quality in relation to broodstock condition. Aquaculture, 227: 107-130.

Ravid, T., A. Tietz, M. Khayat, E. Boehm and R. Michelis (1999). Lipid accumulation in the ovaries of a marine shrimp *Penaeus semisulcatus* (De Haan). The Journal of experimental biology, 202 (Pt 13): 1819-1829.

Rosenberry, B. (2011). Shrimp news international. Oberon FMR.

Sudaryono, A., M. J. Hoxey, S. G. Kailis and L. H. Evans (1995). Investigation of alternative protein sources in practical diets for juvenile shrimp *Penaeus monodon*; Aquaculture, 134: 313-323.

Vijayan, K. K., C. P. Balasubramanian, S. Kannappan, M. Jayanthi, A. Panigrahi, P. N. Rekha, ... and R. Aravind (2018). Training Manual On Recent Advances In Farming Of Pacific White Shrimp, *Penaeus vannamei*.

Wouters, R., P. Lavens, J. Nieto and P. J. A. Sorgeloos (2001). Penaeid shrimp broodstock nutrition: an updated review on research and development. Aquaculture, 202(1-2): 1-21.

Yano, I. (2000). Endocrine control of reproductive maturation in economically important crustacea for aquaculture. In Adiyodi, K.G. and R. G. Adiyodi (Eds.), Reproductive Biology of Invertebrate. Wiley. New York, p. 161-194.

دراسات تناسلية على إعداد قطيع من أمهات الجمبري ذو الأرجل البيضاء في المفرخات التجارية

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أجريت الدراسة الحالية لتحديد وتحليل أفضل الممارسات التي يمكن إتباعها في مفرخات الجمبري الفانمي ذو الأرجل البيضاء للإعداد الجيد لقطيع الأمهات لمده ٣٠ يوم وبيان مدي جاهزية الأمهات لبدء موسم التفريخ حيث تمت الدراسة علي تحديد اثر استخدام نوعين من الديدان وبيان تأثيرهما علي الأداء التناسلي لقطيع الأمهات وتمت الدراسة من خلال ٣ برامج تغذيه حيث كانت المعاملة الأولي بتغذية ١٠٠٪ من نسبة الديدان من النوع الأول (ديدان الدم) والمعاملة الثانية تغذيه ٥٠٪ من النوع الأول و٥٠٪ من النوع الثاني والمعاملة الثالثة تغذية ١٠٠٪ من النوع الثاني وقد تم تقييم التجارب من حيث (جاهزية الأم لرمي البيض- تطور المناسل - عدد البيض -نسبة الفقس- عدد اليرقات- عدد دورات التفريخ – الزيادة في الوزن- معدل الاستفادة من الغذاء - كمية الغذاء المأكول) وأوضحت النتائج أن بروتوكول التغذية الذي يحتوي علي ديدان الدم من النوع الأول أدي إلي الزيادة المعنوية في جوده وكفاءة الأداء التناسلي للجمبري الفانمي حيث احتوائها علي النصيب الأكبر من نسبة البروتين, الفيتامينات, الأملاح المعدنية، الأحماض الأمينية والأحماض الدهنية الغير مشبعة والتي لها أهميه كبري في عملية التفريخ وإنتاج البويضات. في هذه الدراسة، أظهر نظام التغذية T1 الذي يتكون من ١٢٪ ديدان الدم، و ١٢٪ حبار ، و ١٪ حبيبات جافة أفضل أداء تناسلي للجمبري الفانمي من نظم التغذية الأخرى.